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Dyspnea in pregnancy

Volker Lehmann

Dept. of Gynecology, University of Würzburg
(Chairman: Prof. Dr. K. H. WULF)

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COMROE et al. [1] define dyspnea in their book "The Lung" as a **subjective symptom** only sensed by the patient, the severity of which can only be gauged by the patient, as is true for other sensations. **Dyspnea at rest occurs in 20% of pregnant women** already in the 12th week of pregnancy. During a slight physical load 60% of pregnant women report that they are short of breath [2]. No satisfactory explanation for this symptom has, as yet, been found.

Pulmonary functions were examined in 23 women during pregnancy and after delivery. Eight of these reported shortness of breath at rest already from the 10th to 12th week of gestation. The values for their lung function tests were compared with those of 15 women not suffering from dyspnea.

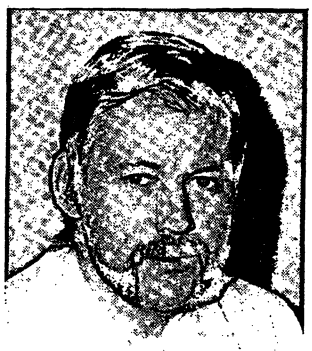
1 Material and methods

Twenty three pregnant women aged 21 to 34 years were examined. The course of pregnancy was normal. All delivered spontaneously at the end of gestation. Pulmonary functions were examined in the **12th, 24th, 32nd and 36th weeks of pregnancy.** The same subjects were re-examined 12 weeks after delivery in order to obtain control values. Eight patients spontaneously reported shortness of breath between the 10th and 12th week of pregnancy. Their pulmonary functions in the 12th week of gestation were compared with those of the remaining 15 women.

Lung volume, ventilation, respiratory mechanisms and **diffusion capacity** were examined in all 23 women. The cause of dyspnea in the first trimester was sought and hence the following parameters were of interest: **oxygen consumption, minute volume, compliance, respiratory work against viscous resistance,** and **diffusion capacity.**

These techniques, as used here, are routine in any larger laboratory for pulmonary functions [2]. Hence only the principle of the method is given. Lung volume and ventilation were determined with a closed system of a spirometer ("Pulmotest" GODART). This apparatus has two complete systems with spirometers, absorbers and the change in volume of both is recorded on a common kymograph. The left system is filled with a helium air mixture, the right one with oxygen. The amount of oxygen consumed by the subject is automatically replaced via an electromagnetically controlled valve and oxygen consumption is thus read from the change in volume of the gas supply bottles.

Curriculum vitae



Born in Kiel in 1938. Studied and graduated in Kiel, 1963. University of Kiel, Dpt. of Obstetrics and Gynecology, for 3 years as intern. 1969: Intern and resident at the medical Faculty, Dpt. Obstetrices and Gynecology, Hannover. 1973 habilitation. Since 1973 senior resident at the Dpt. of Obstetrics and Gynecology, University Würzburg.
Research into acid base metabolism in mother and fetus at birth. Changes in oxygen affinity of fetal blood, energy turnover and hemodynamics at birth and pulmonary function during pregnancy.

An esophageal baloon technique was used to determine the volume-pressure coefficient (compliance). Respiratory work against a viscous resistance was calculated by planimetry of the recorded respiratory loop.

Diffusion capacity for CO was determined by the method of KROGH as modified by FORSTER et al. [4]. The amount of CO that diffuses through the alveolar wall into the blood per mg Hg pressure difference while the breath is held, is determined.

Means, standard errors and standard deviations were calculated. The significance of differences was tested using the t-test for two independent variables and for pair differences.

2 Results

Individual values, means and standard deviations are shown in Tabs. I to V.

a) **Minute volume:** In women, not complaining of dyspnea early in pregnancy, a MV of 7,9 l/min was found when they were not pregnant. In the 12th week of pregnancy this had risen to 8.3 l/min ($2p < 0.05$). In dyspneic women the MV rose from 8.4 l/min outside of pregnancy to 10.1 l/min in the 12th week ($2p < 0.01$) (Tab. I).

Tab. I. Minute volumes in 15 women without dyspnea and 8 women with dyspnea determined outside of and in the 12th week of pregnancy (l/min).

without dyspnea		with dyspnea	
outside	12th week	outside	12th week
7.1	6.1	8.3	11.8
5.3	7.6	8.0	8.7
8.5	8.8	8.9	11.9
7.3	7.7	7.6	8.6
9.1	6.6	8.4	9.2
6.7	8.6	7.9	9.3
8.4	9.3	9.3	10.8
9.7	8.8	9.3	10.6
8.7	9.2		
7.6	8.1	$\bar{x} = 8.5$	$\bar{x} = 10.1$
8.2	8.6	$S = 0.6$	$S = 1.3$
8.5	10.1		
7.8	9.0		
8.1	8.5		
7.8	8.0		
$\bar{x} = 7.9$	$\bar{x} = 8.3$		
$S = 1.1$	$S = 1.0$		

Tab. II. Compliance in 14 women without dyspnea and 7 women with dyspnea outside of and in the 12th week of pregnancy (ml/cmH_2O).

without dyspnea		with dyspnea	
outside	12th week	outside	12th week
205	228	176	172
130	135	124	122
161	151	150	134
132	138	143	167
224	216	163	192
138	123	132	122
200	212	183	195
268	262		
265	280	$\bar{x} = 153.0$	$\bar{x} = 157.7$
248	206	$S = 22.1$	$S = 31.5$
218	230		
194	150		
172	184		
170	173		
$\bar{x} = 194.6$	$\bar{x} = 192.0$		
$S = 46.7$	$S = 49.1$		

b) **Tidal volume:** This was 544 ml air for normal women and 554 ml for those with dyspnea and rose to 599 and 655 respectively in the 12th week of pregnancy.

c) **Respiratory rate:** All women had 15 respirations per min within and outside pregnancy.

d) **Compliance:** This was 194 ml/cm H_2O after delivery in normal women and 153 in the dyspneic group. In the 12th week of pregnancy the figures were 192 and 153 respectively (Tab. II).

e) **Viscous respiratory work:** In the control group we calculated 2.6 gcm/ml both during and after the end of pregnancy. In the dyspneic group the values were 2.8 after delivery and 2.9 gcm/ml in the 12th week of pregnancy (Tab. III).

f) **Diffusion capacity.** In nonpregnant controls this was 26.4 ml/min/mmHg. No change was found in the 12th week of pregnancy (26.1 ml). In dyspneic women, however, the

Tab. III. Viscous respiratory work in 14 women without dyspnea and 7 women with dyspnea outside of and in the 12th week of pregnancy (gcm/ml).

without dyspnea		with dyspnea	
outside	12th week	outside	12th week
3.5	3.3	2.3	2.1
2.0	2.2	2.8	3.3
2.3	1.7	3.0	3.5
4.7	4.9	2.1	2.3
4.2	4.1	3.6	3.8
2.9	3.5	4.8	5.0
1.0	0.5	1.0	0.8
3.0	2.8	$\bar{x} = 2.8$	$\bar{x} = 2.9$
2.6	2.1	$S = 0.9$	$S = 0.7$
2.2	2.5		
1.9	1.6		
2.3	2.0		
2.0	2.2		
3.0	3.0		
$\bar{x} = 2.6$	$\bar{x} = 2.6$		
$S = 0.9$	$S = 0.8$		

Tab. IV. Diffusion capacity in 15 women without dyspnea and 8 women with dyspnea outside of and in the 12th week of pregnancy (ml/min/mmHg).

without dyspnea		with dyspnea	
outside	12th week	outside	12th week
27.3	28.6	28.4	27.9
23.5	22.5	27.6	26.1
22.4	23.5	22.4	20.0
23.3	23.3	25.5	22.6
27.4	26.6	28.5	21.0
23.2	23.1	27.8	27.1
28.7	26.6	27.0	26.8
27.4	27.0	26.4	25.3
26.8	26.0	$\bar{x} = 26.7$	$\bar{x} = 24.6$
21.2	21.2	$S = 2.0$	$S = 3.0$
30.8	32.1		
33.5	33.3		
26.8	26.0		
24.7	24.0		
28.9	28.1		
$\bar{x} = 26.4$	$\bar{x} = 26.1$		
$S = 3.4$	$S = 3.4$		

Tab. V. Oxygen uptake in 15 women without dyspnea and in 8 women with dyspnea determined outside of and in the 12th week of pregnancy (ml/min).

without dyspnea		with dyspnea	
outside	12th week	outside	12th week
218	217	186	191
188	200	223	233
235	245	187	216
201	220	203	204
186	227	231	226
204	257	201	242
210	199	235	259
254	279	222	240
212	233		
232	216	$\bar{x} = 212.1$	$\bar{x} = 226.4$
245	230	$S = 18.9$	$S = 22.0$
290	264		
248	252		
215	231		
230	235		
$\bar{x} = 224.5$	$\bar{x} = 233.7$		
$S = 27.5$	$S = 22.6$		

value is already decreased in the 12th week from 26.7 ml/min/mmHg to 24.6 ml ($2p < 0.01$) (Tab. IV).

g) **Oxygen consumption:** This is increased in both groups already in the 12th week of pregnancy ($2p$ for both groups < 0.05) and is the same in both groups (Tab. V).

3 Discussion

It is noteworthy that the **diffusion capacity is significantly decreased in the 8 dyspneic women** in the 12th week of gestation ($2p < 0.01$) **but remains unchanged in the control group.** In the 12th week of pregnancy the difference between the two groups is significant for $2p < 0.05$. **As the diffusion capacity decreases** in the dyspneic group **hyperventilation sets in.** Outside of pregnancy the minute volume of these women was 8.4 l and this rose to 10.1 l in the 12th week of pregnancy, i. e. a rise of 20%. In the control group the rise was from 7.9 to 8.3 l/min, i. e. only 5%. The difference between the two groups in the 12th week of pregnancy is significant for $2p < 0.01$. **The increased minute volume** in the dyspneic group **is due to a larger increase in the tidal volume. The respiratory rate is the same in both groups (15 min).** Hence the rise in minute volume is solely due to an increase in the tidal volume. In the control group the tidal volume increases by 55 ml in the 12th week while in the dyspneic group the increase is 101 ml, i. e. 10% in the control and 19% in the dyspneic group. Although oxygen consumption is increased already in the 12th week of gestation in both groups, there is no difference between them, inspite of the significantly higher minute volume in the dyspneic women. In other words in early pregnancy **dyspneic women do not show a greater rise in oxygen consumption** although their minute volume is raised. Hence these women must ventilate more in order to achieve the same rate of oxygen consumption as found in the controls. The extra work required for this increased ventilation is felt as shortness of breath. These findings may be explained by an increased impairment of diffusion in the dyspneic group. Dyspnea appears at a time when the diffusion capacity is significantly decreased. In control pregnant women oxygen consumption and hence ventilation and respiratory effort are also raised. This increased effort is felt as dyspnea only in those women, in whom the impairment of diffusion is strong enough to make increased hyperventilation necessary. In normal women the diffusion capacity also decreases significantly as pregnancy progresses and for them it is also

possible to make this decrease responsible for the further increase in hyperventilation [4]. Not only the necessary increase in oxygen consumption leads to increased ventilation. **The oxygen consumption does not rise at the same rate as the minute volume.** WULF [11] has calculated a partial pressure of oxygen of 105 to 110 Torr for the degree of hyperventilation at the end of pregnancy. The actual figure however, was only 92 Torr. BARTELS et al. [2] and ROOTH [9] and also VASIKA [10] found **no significant difference in the pO_2 between pregnant and non pregnant women.** The arterial pCO_2 decreases significantly during pregnancy. Since CO_2 diffuses much more readily than O_2 it decreases during hyperventilation. HEIDENREICH et al. [5] found an increased flow resistance after the 25th week of pregnancy. This is contradicted by the finding that often dyspnea occurs already in weeks 10 to 12, i. e. at a time when according to this author [5] the flow resistance has not yet altered.

In addition we found **no significant changes in compliance in our women,** nor did we find a change in the work against viscous resistance. This respiratory resistance consists of tissue resistance and respiratory pathways resistance, with 20% due to the tissues and 80% to the pathways. An increase in the resistance of the latter would thus have to lead to increased respiratory work against a viscous resistance and this was found not to be the case.

We believe, on the basis of our data, that **dyspnea in early pregnancy is due to a fall in the diffusion capacity of the lungs.** This may be explained by a rise in the diffusion distance. There may be a causal relationship to the increased level of estrogen in pregnant women. This is discussed elsewhere [6]. It should be mentioned, however, that an intravenous injection of estriol given experimentally, may cause a fall in diffusion capacity and a simultaneous rise in ventilation.

Summary

In 20% of pregnancies, dyspnea at rest occurs as early as the 12th week of gestation, and **60% of women in pregnancy complain of dyspnea following moderate exertion.** In order to clarify this dyspnea, the pulmonary function studies of 23 women were examined in the 12th, 24th, 32nd and 36th week of gestation and also at 12 weeks post partum. Eight patients complained of dyspnea at rest as early as the 10th and 12th week of gestation. The changes of ventilation were determined by measurement of tidal, respiratory rate and minute ventilation. O_2-uptake, working against total pulmonary resistance, compliance and diffusion capacity were the other parameters measured in this study. The oxygen uptake was reduced to standard condition and dry (STPD). By means of an esophageal ballon technique compliance and working against total pulmonary resistance were investigated. Diffusing capacity was determined by the breath-holding technique. There was a significant decrease of the diffusion capacity in the 12th week in all 8 dyspneic women, although no changes were observed in the control group **(Tab. IV).** The fall of diffusion capacity during pregnancy is explained by an estrogen effect on capillary and alveolar walls and the interstitial tissue of the lung. **Minute ventilation** in the dyspnoic group increased by 20% in the 12th week, while only by 5% in the controls **(Tab. II).** The increase in minute ventilation is implemented primarily by an increase in tidal volume. No change of respiratory rate is noticed. Inspite of the significant increase of minute ventilation in dyspneic women, there is no significant difference in the **O_2-uptake** as compared to the controls **(Tab. V).** No differences of **compliance** and working against total **pulmonary resistance** are measured **(Tab. II and III).** These data indicate that women with dyspnea in early pregnancy have to compensate for the diffusion efficiency by increased ventilation, in order to reach an O_2-uptake comparable to the normal control group. This greater amount of energy involved in breathing is designated as dyspnea by the pregnant women.

Keywords: Diffusion capacity, dyspnea, pregnancy, pulmonary functions.

Zusammenfassung

Untersuchungen zur Frage der Schwangerendyspnoe

Bei 20% der Schwangeren tritt eine Dyspnoe in Ruhe schon in der 12. Schwangerschaftswoche **auf. 60% der Schwangeren geben eine Kurzluftigkeit bei geringerer körperlicher Belastung an.** Um die Ursachen dieser Dyspnoe zu klären, wurden 23 Frauen in der 12., 24., 32. und 36. Schwangerschaftswoche sowie 12 Wochen nach der Entbindung auf ihre Lungenfunktion hin untersucht. 8 Frauen aus diesem Kollektiv gaben eine Ruhedyspnoe bereits in der 10.—12. Schwangerschaftswoche an. Um die Veränderungen der Ventilation zu erfassen, wurden Atemzugvolumen, Atemfrequenz und Atemminutenvolumen mit einem Spirometer gemessen. Weiterhin wurden die O_2-Aufnahme, die Compliance, die Atemarbeit gegen visköse Widerstände und die Diffusionskapazität untersucht. Die Werte über die Messung der Sauerstoffaufnahme

wurden auf Standardbedingungen bezogen (STPD). Compliance und die Atemarbeit gegen visköse Widerstände wurden mit Hilfe einer Oesophagussonde registriert und errechnet. Die Diffusionskapazität wurde durch Messung der CO-Diffusion mit Atemanhaltetechnik bestimmt. Bei den 8 dyspnoischen Frauen nimmt die Diffusionskapazität zur 12. Schwangerschaftswoche signifikant ab, während sie bei den Frauen der Kontrollgruppe gleich bleibt (s. **Tab. IV**). Die Abnahme der Diffusionskapazität wird durch einen Östrogeneffekt auf Kapillar- und Alveolarwand sowie das interstitielle Gewebe der Lunge mit Einlagerung von sauren Mucopolysacchariden erklärt. Das Atemminutenvolumen steigt bei den Frauen mit Dyspnoe in der 12. Woche um 20% an, in der Kontrollgruppe nur um 5% (s. **Tab. II**). Die Zunahme des Atemminutenvolumens ist ausschließlich durch eine Steigerung des Atemzugvolumens bedingt. **Die Atemfrequenz ändert sich nicht.** Compliance und die Atemarbeit gegen visköse Widerstände bleiben unverändert (s. **Tab. II** und **III**). Trotz dieser signifikant stärkeren Zunahme des Atemminutenvolumens bei den Frauen mit Dyspnoe, kommt es zu keiner signifikant stärkeren Zunahme der O_2-Aufnahme gegenüber den Frauen ohne Dyspnoe. Das bedeutet, daß die Frauen mit einer Dyspnoe in der Frühschwangerschaft mehr ventilieren müssen, um bei der bestehenden Diffusionsstörung die gleiche Sauerstoffaufnahme zu erreichen wie die Schwangeren ohne Dyspnoe. Die mit dieser stärkeren Ventilation erhöhte Atemarbeit wird von den Schwangeren als Dyspnoe empfunden.

Schlüsselwörter: Diffusionskapazität, Dyspnoe, Lungenfunktion, Schwangerschaft.

Résumé

Examples relatifs à la dyspnée de grossesse

Chez 20% des femmes enceintes on observe une dyspnée au repos dès la 12ème semaine de grossesse. **60% des femmes enceintes enregistrent une gêne respiratoire au moindre effort physique.** Afin de préciser les causes de cette dyspnée nous avons examiné la fonction pulmonaire de 23 femmes au cours des 12ème, 24ème, 32ème et 36ème semaines de grossesse ainsi que 12 semaines après l'accouchement. Parmi ce groupe, 8 femmes ont révélé une dyspnée de repos dès la 10—12ème semaine de grossesse. Pour enregistrer les changements de ventilation on a mesuré le volume du souffle, la fréquence respiratoire et le volume respiratoire par minute à l'aide d'un spiromètre. Ont été également examinés l'absorption d'oxygène, la compliance, le travail respiratoire contre les résistances visqueuses et la capacité de diffsuion. Les valeurs sur la mesure de l'absorption d'oxygène ont été rapportées à des conditions standard (STPD). La compliance et le travail respiratoire contre les résistances visqueuses ont été enregistrés et calculés à l'aide d'une sonde de l'oesophage. La capacité de diffusion a été déterminée par la mesure de la diffusion CO avec la technique de retention du souffle.

Chez les 8 femmes dyspnoiques, la capacité de diffusion à la 12ème semaine de grossesse baisse de façon significative tandis qu'elle reste stationnaire chez les femmes du groupe de contrôle (cf. **Tab. IV**). La baisse de la capacité de diffusion s'explique par un effet d'oestrogène sur la paroi capillaire et alvéolaire ainsi que le tissu interstitiel du poumon avec le dépôt de mucopolysaccharides acides. La capacité pulmonaire monte de 20% chez les femmes dyspnoiques dans la 12ème semaine de grossesse et de 5% seulement chez le groupe de contrôle (cf. Tab. II). La hausse de la capacité pulmonaire est conditionnée exclusivement par une augmentation du volume de souffle. **La fréquence respiratoire ne change pas.** La compliance et le travail respiratoire contre les résistances visqueuses restent inchangés (cf. **Tabs. II et III**). Malgré cette hausse nettement plus accentuée de la capacité pulmonaire chez les femmes dyspnoiques, on n'observe aucune augmentation significativement plus forte d'absorption de O_2 par rapport aux femmes sans dyspnée. Cela signifie que les femmes dyspnoiques en début de grossesse doivent davantage ventiler pour atteindre, en présence du trouble persistant de diffusion, la même absorption de O_2 que les femmes enceintes non dyspnoiques. L'augmentation du travail respiratoire consécutive à cette ventilation plus forte est ressentie comme une dyspnée par les femmes enceintes.

Mots-clés: Capacité de diffusion, dyspnée, fonction pulmonaire, grossesse.

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Priv.-Doz. Dr. med. V. Lehmann
Universitäts-Frauenklinik
und Hebammenschule
8700 Würzburg
Josef-Schneider-Str. 4